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Municipal waste management in context of sustainable urban development

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Abstract

Municipal waste management is an element of environmental order marking which is one of the areas of sustainable development. This article draws attention to the problem of municipal waste management in the context of sustainable urban development. The purpose of the article is a dynamics analysis in terms of municipal waste management characteristics in urban areas. Selected Polish voivodships and cities are examined across a set of variables comprised of the following measures: collected mixed municipal waste, collected mixed municipal waste from trade, small business, collected mixed municipal waste from municipal services, collected mixed municipal waste from households, mixed municipal waste from households in selected health resorts and number and area of controlled landfill sites in operation. The analysis is based on data from the years 2004 and 2012.

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Keywords: municipal waste management; sustainable development; environmental order; sustainable urban development

1. Introduction

The concept of sustainable development finds its place not only in various types of human activity, but also in different forms of social organization such as the city whose development depends on environmental and natural circumstances. Due to the increasing number of city dwellers and growing consumption, urbanization can have detrimental effects on urban communities. That necessitates employing the concept of sustainable development in

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the functioning of cities to protect both urban communities and the ecosystem.

The generation of waste is intrinsic to urbanization. Municipal waste in 2012 constituted 9% of all waste in Poland. The communal cleanliness and order maintenance act binds municipalities to organize the system of municipal waste management. Protection against this type of waste is conditioned by environmental, social and economic circumstances and for this reason it becomes an element of cities' sustainable development. This article draws attention to the problem of municipal waste generated in urban areas in the context of sustainable development. The aim of this article is to analyze the dynamics of municipal waste quantities and the ways of managing it in the year 2012 in comparison to the year 2004. The year which observed the effects of the environmental protection methods, which concerned also municipal waste, implemented at the turn of the century is the benchmark.

2. Basic premises of the sustainable development of cities

Economic progress results in a dynamic development of cities. In 2050 three quarters of the world's population will live in urban environment. The high tempo of urbanization is one of the major challenges nowadays and calls for adequate planning solutions to the development of cities, and for new management systems which can form communities economically, socially and ecologically sustainable (Pearson, 2013).

Urbanization and economic development have brought significant alterations to the urban landscape (Chen, & Wang, 2013). The urban area is an ecosystem which has been touched by the biggest environmental changes caused by human activities. It is densely populated and has an expanded structure and infrastructure (Zhenming, & Bin, 2013). Research shows that the amount of greenery and open areas in cities translates into the health and mood of people (McDonnell, & Hahs, 2013). Therefore, it is important to organize in cities the so called green infrastructure understood as "a connected network of multifunctional, predominately unbuilt, space that supports both ecological and social activities and processes" (Schäffler, & Swilling, 2013). The elements of green infrastructure are: street trees, private and public gardens, parks, riparian zones along urban drainage lines, undeveloped ridges, and a variety of urban agricultural spaces such as food-and community-based gardens. They contribute to the urban ecosystem's good condition. Apart from environmental benefits, investments into green infrastructure yield also economic and social perks stemming from the services of the ecosystems which are presented in table 1. Maintaining the nature's ability to mitigate the negative effects of environmental changes is definitely less costly than replacing its function with technical solutions. Moreover, ecosystem services help ensure the good quality of life for communities, both now and in the future.

Table 1. Categories of ecosystem services (adapted from Jansson, 2013)

Type of functions	Definition
Regulation functions	Regulation functions help maintain the delicate balance of the earth's biosphere, human life support system e.g. prevention of soil erosion, storage and recycling of nutrients, purification of air and water, generation of top soils, maintenance of biological diversity and regulation of the chemical composition of the atmosphere.
Habitat functions	Habitat functions provide space and a substrate for e.g. cultivation, recreation and tourism.
Production functions	Production functions provide resources e.g. oxygen, water, food, medicines, fertilizers and energy.
Information functions	Information functions provide opportunities for e.g. esthetic and cultural enrichment, recreation, research and education.

This makes the level of sustainability of cities an important aspect of their development. Urbanization has become a major issue in the sustainable development debate, mainly because of the problems concerning the intelligent planning and development (McCormick, Anderberg, Coenen, & Neij, 2013). The implementation of the concept of sustainable development in cities is seen as a way for the improvement of ecosystems and, accordingly,

the life of urban dwellers (Jim, 2013). The difficulty for the sustainable development in cities comes out of the divergence between the pursuit of more densely populated, energy-efficient cities and the need for developing green infrastructure which can be used by ecosystems and ensure the biodiversity of the environment in which people live and work (Mörtberg, Haas, Zetterberg, Franklin, Jonsson, & Deal, 2013). Subject literature determines mainly three theoretical approaches to the concept of sustainable development: "the inter-generational and intra-generational equity and justice perspective, the comprehensive environmental, economical, equitable change perspective, and the free-market greening perspective" (Zheng, Shen, & Wang, 2014). Inter- and intra-generational equities allow for the integration of the three dimensions of sustainable development: environmental, social and economic. Inter-generational equity is to safeguard the life of future generations and maintain the quality of the environment through the continuity of natural resources. Intra-generational equity ensures the fair access to the resources for present generations in terms of food, accommodation, fresh water and employment (Vojnovic, & Darden, 2013). Unfortunately, there is a shortage of research on the role of the state in the implementation of sustainable development in cities. We are not certain how to tackle the development of all sorts of programs connected with this matter nor do we have vast information on creating proper institutional and social structures supporting the sustainable human activity. In order to increase the problem awareness of sustainable development in cities, the United Nations Human Settlements Program (UNHabitat) has been created. It has set up the Sustainable Urban Development Network (SUDNet) comprised of global partners promoting a multilateral and interdisciplinary approach to sustainable urban development (Shaalan, 2013).

The subject literature does not define the sustainable development of cities in a clear-cut way. We could determine it as 'the social, economic, and physical organization of urban populations in ways that accommodate the needs of current and future generations, while preserving the natural environment and its ecological systems over time" (Vojnovic, & Darden, 2013). The sustainability of a city can be understood as „a practice that uses resources efficiently and improves the quality of life in an excellent environment within the constraints of our earth" (Shen, Peng, Zhang, & Wu, 2012). Haas and Troglio distinguish three aspects of the sustainable development of cities: environmental, social and economic (Haas & Troglio, 2013). The definitions of those aspects were presented in table 2.

Table 2. Basic aspects of sustainable urbanism.

Aspects	The definitions given by Haas and Troglio (Haas & Troglio, 2013)
Environmental	An urban form enables its inhabitants to adopt a more ecologically aware, lower carbon lifestyle.
Social	Sustainable urbanism involves an appropriate mix of dwellings of different tenures, sizes and types, and a variety of spaces and buildings for recreational and community activities, as well as for service providers and commercial enterprises.
Economics	Sustainable developments contain business activities and opportunities capable of providing jobs for many of their inhabitants across the social and economic spectra.

One of the pillars of sustainable development is the sustainable consumption understood as consumption that simultaneously optimizes the environmental, social, and economic consequences of acquisition, use and disposition in order to meet the needs of both current and future generations" (Phipps, Ozanne, Luchs, Subrahmanyan, Kapitan, Catlin, Gau, Naylor, Rose, Simpson, & Weaver, 2013). It is significant due to the depletion of resources caused by the excessive consumption in cities. The quantity of municipal waste reflects the level of goods going to waste. The implementation of appropriate municipal waste management leading to the minimization of waste plays an important role in the sustainable development of cities.

3. Municipal waste management as an element of the sustainable development of cities

Cities are the motor of economic activities. But the functioning of every city generates waste. The dynamic economy leads to the increase of goods flow and thus to the growth of waste (Chwesiuk, Kijewska & Iwan, 2010).

Subject literature offers many classifications of waste according to the specified criteria. According to its origin, waste can be categorized as industrial or municipal. The waste act from 14 December 2012 (Dz.U. 2013 poz. 21) defines municipal waste as waste generated in households, excluding exploited vehicles, or non-toxic waste generated elsewhere which is similar in its form and composition to household waste; mixed municipal waste remains municipal waste after processing which does not change its form significantly.

Waste is usually associated with an ineffective functioning of communities and squandering resources. Waste generation is associated with the growing number of town users (Kijewska, Iwan & Kaczmarczyk, 2012). Although cities take up only 2% of global space, they use over 75% of resources and generate 70% of all the waste in the world (Zaman, & Lehmann, 2013). Waste generation is linked with the dwindling of natural resources, water consumption, negative environmental impact and creating additional costs of waste management. Environmental awareness of entrepreneurs and citizens may reduce the negative influence on the natural environment (Seroka-Stolka, 2011). The need for the reduction of waste resulted in an innovative 'zero waste' city concept. In fig.1 the key principles of the zero waste city is presented.

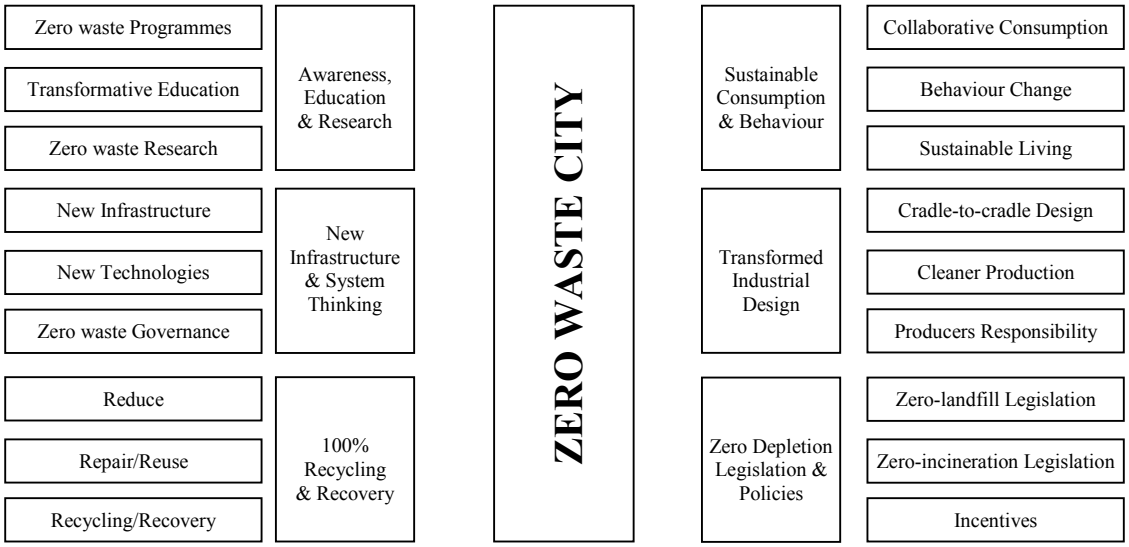

Fig. 1. Drivers for transforming current cities into zero waste cities. Source: (Zaman, 2013).

The proper realization of all rules governing the municipal waste management can break ground for zero waste cities. Key factors here are based on the implementation of the short and long-term strategies. Awareness and education, behaviour change and systems thinking are among the long-term strategies, where as innovative industrial design, legislation and 100% recycling are short-term strategies.

In many cities, especially in the developing countries, the environment and, accordingly, the health of dwellers is degraded because the municipal waste management systems are not effective (Getahun, Mengistie, Haddis, Wasie, Alemayehu, Dadi, Van Gerven, & Van der Bruggen, 2012). Most waste is landfilled which challenges the cities to find areas suitable for it. Moreover, landfilling is a costly form of waste neutralization which is not socially accepted and must meet strict legal and administrative requirements (Pandey, Sharma, & Nathawat, 2012). Landfilled waste is especially hazardous because it is the source of methane which is one of the greenhouse gases (Thanh, & Matsui, 2013). That is why wherever the prevention of waste is not possible, waste recovery is the desired way of managing it. Municipal waste is where we find resources that can be recovered with the lowest energy and external means expenditure (Noma, Ide, Yoshikawa, Kojo, Matsui, Nakajima, & Imai, 2012). The socio-economic spin-offs of recycling are profits for recovery businesses and the community itself (Menikpura, Gheewala, Bonnet, & Chiemchaisri, 2013) as the waste management system is composed of multiple waste collection centers and disposal

plants with a series of supply-disposal relationships. These realize activities from the collection of waste to the delivery of treated waste to the end disposal facilities (Zhang, Huang, & He, 2014).

Miyata et al showed in their research that "the treatment of municipal waste is well-organized in cities that experience higher income and growth of the waste, and developed effective municipal solid waste disposal process" (Miyata, Shibusawa & Hossain, 2013). With that in mind, they worked out a relationship between the economic level, city expenditure, and municipal waste, which is expressed by the following function:

Municipal Waste ≡ f (Economic Level, City Expenditure, Population).

The variables are: per capita economic level (calculated based on manufacturing, agriculture and trading output of the city), per capita city expenditures on municipal waste management (calculated from the city accounts), and per capita volume of municipal solid waste generated in the city. The analysis led to the following conclusions:

- economic level of the city can be explained for higher generation of municipal waste over the time periods,
- municipal waste generation can be explained by the city expenditure for waste management over the time periods.

Summing up, public investment is necessary in the implementation of sustainable development in cities. Municipal waste management investments contribute mainly to the effects in the field of environmental governance, and, indirectly, to the economic and social aspect of sustainable development.

4. The problem of municipal waste on the example of selected Polish cities

Municipal waste is a significant problem in cities not only quantity-wise, but also in terms of its neutralization methods. Regional development strategies in Poland are commonly complemented by more specific strategies concerning waste management (Nitkiewicz, 2010). Waste management systems are developed on the basis of the communal cleanliness and order maintenance act from 13 September 1996 (Dz.U. 1996 nr 132 poz. 622). According to the amendment (act from 1 July 2011, Dz.U. 2011 nr 152 poz. 897), the organization of waste management is the responsibility of municipalities which tackle all activities serving local communities. Therefore, the city controls every part of its waste management system. In order to build an effective waste management system, it is necessary to understand the scale of the municipal waste problem. This article analyzes the basic measures characterizing waste management in Polish cities in the years 2004 and 2012.

The quantity of collected waste and the area of landfills are important elements of urban waste management because landfilling is still the most popular method of waste neutralization in cities. Table 3 shows the rates of relative growth based on a fixed value (2004=100%) for waste collected from public and private sectors in 2012.

Table 3. Rates of relative growth based on a fixed value(2004 = 100%) for municipal waste collected from public and private sectors in 2012 [%].

Specification	Grand total	Cities
Collected municipal waste (in thous. tones)	98.17	83.69
Number of controlled landfill sites in operation	50.24	58.18
Area of controlled landfill sites in operation (in ha)	64.92	74.22
Area of controlled landfill sites in operation reclaimed during the year (in ha)	305.21	223.08
Number of closed controlled landfill sites	69.32	52.94
Area of closed controlled landfill sites (in ha)	76.62	38.43
Area of closed controlled landfill sites reclaimed during the year (in ha)	144.50	27.59

Compared to the year 2004, the quantity of collected municipal waste generated in cities in 2012 was lower by as much as 16.31%, but in terms of the quantity of municipal waste collected in total, the decrease is as little as 1.83%.

That raises the question as to whether the decrease of the municipal waste quantity might be due to its disposal to illegal landfill sites. The decrease of the quantity of collected municipal waste is accompanied by the drop in the number and area of landfill sites in the year 2012 in comparison to 2004. In the cities, the decrease in the number and the area of landfills was 41.82% and 25.78% respectively, and was bigger than the decrease in the number and the area of landfill sites in the public and private sector by 7.94% and 9.30% respectively. That translates into the increase of the area of restored landfills in operation – by 123.08% in cities and by as much as 205.21% in the public and private sector. 47.06% fewer landfill sites were closed in 2012 compared to 2004, which can also be expressed with reference to their area – 61.57%. Both these indexes were 30.68% and 23.38% in the public and private sector respectively. Conflicting trends were observed with reference to the area of restored closed landfill sites in the analyzed period. It increased in the public and private sector in 2012 by 44.50% compared to 2004, but decreased in cities by 72.41%. Landfills which do not meet the EU ecological norms are liquidated. The state waste management plan requires that landfills lacking in appropriate infrastructure are closed.

In Poland there are also landfills which are illegal and not supervised. They are a serious threat to the environment and the life and health of people. They can be found mainly in suburban areas, in the vicinity of residential areas, along little-used roads, at the forest borders, in the clumps of trees. They can pollute water, soil and air with hazardous substances and pose an epidemic risk because of the development of harmful microorganisms which can be spread by animals foraging at the landfills.

In many cases the generated municipal waste, due to its properties, can be retrieved through, for example, recycling. On fig. 2 municipal waste selected from households in 2004 and 2012 was presented.

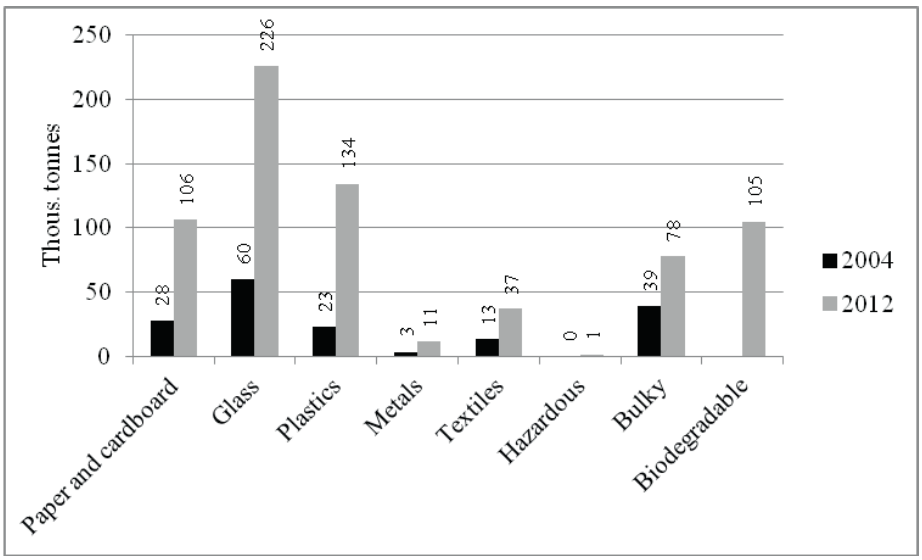

Fig. 2. Amount of selected groups of municipal waste from households in 2004 and 2012.

The quantities of sorted waste in individual groups in 2012 increased significantly in comparison to 2004. In 2012, 10,5% of all municipal waste was sorted - a steep climb from the level of 2,5% in 2004. This dynamic increase in the quantity of sorted municipal waste stems from such incentives for recycling as:

- lower waste collection fees if the household's waste is sorted,
- free-of-charge bags for sorting,
- setting up special collection points by local authorities in places easily accessible for citizens which no longer necessitates households to be equipped with waste bins,
- conducting pro-ecological campaigns by local ecological information centers,
- organizing workshops for different occupational groups concerning the benefits of sorting waste.

Table 4 presents rates of relative growth based on a fixed value (2004 = 100%) for mixed municipal waste collected in selected cities. When it comes to the collected mixed municipal waste in Poland in 2012 in comparison to 2004, there is a downward trend. The analysis of data presented in table 4 reveals drops in: the total quantity of this type of waste (by 9.89%), the quantity of waste per capita (by 10.75%), the quantity of waste generated by trade, small business, office and institutions (by 13.27%), municipal services (by 24.74%) and households (by 7.57%). Downward trends in the measures in terms of collected mixed municipal waste were observed in the majority of cities. The following cities saw an increase in the total quantity of waste and waste per capita in 2012 compared to the year 2004: Wrocław, Bydgoszcz, Lublin, Sosnowiec, Rzeszów. The highest increase occurred in Rzeszów and Lublin – 24.49% and 20.22% respectively. The increase of the quantity of collected mixed municipal waste per capita in Lublin was higher than in Rzeszów, with the levels of 23.24% and 9.44% for the two cities respectively.

Table 4. Rates of relative growth based on a fixed value (2004 = 100%) for mixed municipal waste collected in selected cities [%].

Cities	Municipal waste collected				
	Total	per capita	trade, small business, offices and institutions	municipal services	households
Poland	90.11	89.25	86.73	75.26	92.43
Warszawa	65.55	64.87	41.93	55.00	86.84
Kraków	88.21	88.26	108.11	31.25	84.62
Wrocław	103.37	103.97	67.31	88.89	116.22
Łódź	65.63	70.20	77.27	32.14	62.90
Poznań	56.67	58.57	64.84	175.00	50.19
Gdańsk	89.16	88.63	78.13	130.00	91.30
Szczecin	79.29	79.75	64.29	55.56	86.32
Katowice	89.55	92.73	82.50	140.00	89.89
Bydgoszcz	102.83	105.23	272.73	100.00	82.61
Lublin	120.22	123.24	138.89	700.00	107.14
Gdynia	92.55	94.35	55.88	42.86	122.64
Białystok	54.47	54.37	40.00	66.67	58.89
Gliwice	97.01	104.57	150.00	14.29	100.00
Toruń	97.01	98.29	94.74	60.00	102.33
Sosnowiec	108.62	114.05	85.71	12.50	146.67
Rzeszów	124.49	109.44	100.00	-	128.57
Częstochowa	81.94	85.90	88.24	50.00	80.39
Olsztyn	68.42	68.51	54.55	500.00	69.05
Legnica	83.61	87.08	150.00	100.00	68.89

The analysis of the collected mixed municipal waste generated by individual waste producers in the year 2012 in comparison to 2004 allows for the following conclusions:

- The quantity of waste collected in trade, small business, offices and institutions increased the most in Bydgoszcz – by as much as 172.73%. An increase was also observed in Gliwice and Legnica (50%), Lublin (38.89%), Krakow (8.11%). The quantity of collected mixed municipal waste produced by trade, small business, offices and institutions in Rzeszów remained unchanged. The other cities observed a decrease of this type of waste with reference to small business, offices and institutions – with the biggest drop in Białystok (60%) and Warszawa (58.07%).

- In the case of municipal services, the highest increase of the quantity of waste was evident in Lublin and Olsztyn - 600% and 400% respectively. Other cities with an increase were Poznań (75%), Katowice (40%) and Gdańsk (30%). The same quantities of municipal waste as in the year 2004 were collected in Bydgoszcz and Legnica in 2012. The other cities recorded a decrease in the quantity of municipal waste from municipal services with the steepest drops in Sosnowiec (87.5%) and Gliwice (85.71%).
- Various trends were also observed in the quantitative changes of municipal waste collected in households. Here, the dominant tendency was the decrease of municipal waste in 2012 in comparison to the year 2004. The biggest decrease was observed in Poznań (49.81%) and in Białystok (41.11%), and the smallest in Gdańsk (8.70%)The quantity of collected municipal waste from households increased in Wrocław, Lublin, Toruń, Gdynia, Sosnowiec and Rzeszów, with the biggest increase in Sosnowiec (46.67%). The amount of waste in Gliwice did not change in the analyzed years.

In Poland generally as well as in the majority of selected cities, the downward trend is the main tendency in the quantity of collected municipal waste. The analysis, however, does not allow for a downright assessment of this phenomenon, because it does not examine the causes of the decrease. If it results from a smaller quantity of generated waste, it is very positive - especially in the light of the concept of sustainable development where the amount of waste per capita is one of the measures.

Municipal waste comes from many sources, but the bulk of it is collected from households. Table 5. shows the share of mixed municipal waste collected in such sources of waste generation in mixed municipal waste collected in total.

Table 5. Share of mixed municipal waste collected in such sources of waste generation in mixed municipal waste collected in total [%].

	2012			2004		
Cities	trade, small business, offices and institutions	municipal services	households	trade, small business, offices and institutions	municipal services	households
Poland	24.69	4.15	71.16	25.65	4.97	69.38
Warszawa	29.38	2.01	68.61	45.93	2.39	51.79
Kraków	36.87	2.30	60.83	30.08	6.50	63.41
Wrocław	16.28	3.72	80.00	25.3	4.55	70.15
Łódź	40.26	4.39	55.35	34.06	8.57	57.37
Poznań	28.92	6.86	64.22	25.28	2.22	72.50
Gdańsk	34.06	8.98	56.96	38.55	6.02	55.42
Szczecin	20.25	3.88	75.87	24.94	5.73	69.33
Katowice	27.50	5.83	66.67	29.85	3.73	66.42
Bydgoszcz	27.52	2.75	69.72	10.38	2.83	86.79
Lublin	23.36	6.54	70.09	20.22	1.12	78.65
Gdynia	21.84	3.45	74.71	36.17	7.45	56.38
Białystok	17.91	2.99	79.10	24.39	2.44	73.17
Gliwice	18.46	1.54	80.00	11.94	10.45	77.61
Toruń	27.69	4.62	67.69	28.36	7.46	64.18
Sosnowiec	28.57	1.59	69.84	36.11	12.67	51.22
Rzeszów	32.79	8.20	59.02	41.66	0	58.34
Częstochowa	26.36	3.89	69.75	23.61	5.56	70.83
Olsztyn	34.62	9.62	55.77	43.42	1.32	55.26
Legnica	35.04	5.18	59.78	19.99	5.62	74.39

Municipal waste collected from households constituted the biggest share of all municipal waste collected in both

2004 and 2012. In every analyzed city, household waste constituted more than half of all collected municipal waste. Municipal services waste, on the other hand, had the smallest share in the total quantity of collected municipal waste - not higher than 9.62% in the year 2012 and 13.79% in 2004.

The analysis embraced also cities with the spa status. In table 6 rates of relative growth based on a fixed value (2004 = 100%) for mixed municipal waste collected in selected health resorts were presented. Most of them observed a decrease in both the total quantity of collected waste and the quantity of waste collected from households in the year 2012 compared to 2004. The largest drop in the quantity of collected waste occurred in Polanica Zdrój (48.20%), Kudowa Zdrój (47.04%) and Krynica Zdrój (46.86%). Similarly, the quantity of waste collected from households in these cities in the analyzed years decreased by 49.75%, 62.08% and 40.66% respectively.

Table 6. Rates of relative growth based on a fixed value (2004 = 100%) for mixed municipal waste collected in selected health resorts [%].

	Collected municipal waste	
Health resorts	total	from households
Sopot	141.08	94.83
Inowrocław	78.84	91.66
Kołobrzeg	94.93	89.57
Świnoujście	121.04	84.56
Augustów	74.01	93.11
Ustroń	105.53	87.84
Konstancin Jeziorna	72.28	62.87
Ustka	101.50	85.66
Busko-Zdrój	86.00	54.19
Ciechocinek	117.66	184.64
Kudowa Zdrój	52.96	37.92
Jedlina Zdrój	210.25	144.76
Krynica Zdrój	53.14	59.34
Duszniki-Zdrój	82.06	137.93
Gołdap	83.01	85.05
Polanica Zdrój	51.80	50.25
Szczawno Zdrój	90.66	90.81
Rabka Zdrój	84.12	44.23

When it comes to the quantity of collected municipal waste from households, the biggest decrease was observed in KudowaZdrój (62.08%) and in Rabka Zdrój (55.77%). In cities such as Sopot, Świnoujście, Ustroń, Ciechocinek and Jedlina Zdrój the total quantity of municipal waste increased in the year 2012 in comparison to 2004, with the sharpest increase in Jedlina Zdrój (110.25%). The total quantity of collected municipal waste in the selected spa cities does not always go along with the amount of collected household municipal waste – a situation recorded in Świnoujście, Sopot, Ustroń and Ustka. In these cities, the amount of collected municipal waste in 2012 was bigger than compared to 2004, but it was the other way around in terms of municipal waste collected from households. The quantity of municipal waste collected from households increased only in Ciechocinek, Jedlina Zdrój and Duszniki Zdrój by 84.64%, 44.76% and 37.93% respectively. Ultimately, the spa cities show a downward trend in 2012 compared to 2004 in the quantity of both total collected municipal waste and the municipal waste collected from households. Unfortunately, the analysis does not allow for seeing any regularities in these variables. It is only possible to conclude that compared to the year 2004, in the year 2012:

- the decrease in the total quantity of collected municipal waste was bigger than the decrease of the waste collected from households in Inowrocław, Augustów, Krynica Zdrój, Gołdap and Szczawno Zdrój,
- the decrease in the total quantity of collected municipal waste was smaller than the decrease of the collected household municipal waste in Kołobrzeg, Konstancin Jeziorna, Busko-Zdrój, Kudowa Zdrój, Polanica Zdrój and Rabka Zdrój,
- the increase in the total quantity of collected municipal waste was accompanied by the decrease of municipal waste collected from households in Sopot, Świnoujście, Ustroń and Ustka,
- the decrease in the quantity total of collected municipal waste was accompanied by the increase of collected municipal waste from households only in Duszniki-Zdrój.

Considering the fact that spa cities are characterized by large tourist flows, the problem of municipal waste is also linked with the well developed spa infrastructure. As long as the spa city status promotes sustainable development in terms of environmental governance and some aspects of social governance, it also inhibits the economic progress through certain regulations limiting economic and housing activities in individual resort zones. The collected municipal waste in spa cities comes mainly from households. Table 7 presents the share of collected municipal waste from households.

Table 7. Share of collected municipal waste from households in municipal waste collected in total [%].

Health resorts	2012	2004
Sopot	60.98	90.72
Inowrocław	91.15	78.40
Kołobrzeg	60.37	63.98
Świnoujście	55.58	79.55
Augustów	83.45	66.33
Ustroń	34.24	41.13
Konstancin Jeziorna	64.88	74.59
Ustka	75.78	89.78
Busko-Zdrój	57.68	91.54
Ciechocinek	64.59	41.16
Kudowa Zdrój	42.39	59.20
Jedlina Zdrój	63.38	92.06
Krynica Zdrój	46.27	41.43
Duszniki-Zdrój	53.64	31.92
Gołdap	79.24	77.34
Polanica Zdrój	56.94	58.69
Szczawno Zdrój	92.15	92.00
Rabka Zdrój	40.73	77.46

Comparing the share of collected municipal waste from households in municipal waste collected in total in the years 2012 and 2004, we come to the following conclusions:

- In most analyzed cities the share of collected municipal waste collected from households in municipal waste collected in total in 2012 was smaller than in 2004. In Rabka and Busko-Zdrój the difference exceeds the level of 30%. It can be caused by either a considerable reduction of this type of waste or a steep increase in the quantity of municipal waste from other sources.
- In the majority of the cities the share of the municipal waste collected from households was bigger than 50% in both years. There were exceptions though: Ustroń, Kudowa-Zdrój, Krynica Zdrój i Rabka Zdrój in the year 2012

and Ustroń, Ciechocinek, Krynica Zdrój i Duszniki-Zdrój in the year 2004.Therefore, the municipal waste collected from households is the dominant group of waste.

- The highest share of municipal waste collected from households was observed in Szczawno (92.15%), Inowrocław (91.15%) and Augustów in the year 2012 and in Jedlina Zdrój (92.06%), Szczawno (92.00%), Busko-Zdrój (91.54%), Sopot (90.72%) and Ustka (98.78%) in the year 2004.

The changes in the structure and quantity of municipal waste are caused by various factors, such as:

- demographic factors: population number changes,
- organization factors: changes in the waste collection methods and the size of containers,
- economic factors: waste collection fees,
- social factors: ecological education of city-dwellers, raising the ecological awareness of waste generators, consumption.

Also the organization and functioning of landfills sites is an important aspect of waste management in terms of sustainable development. Table 8 shows rates of relative growth based on a fixed value (2004 = 100%) for controlled landfill sites in operation.

Table 8. Rates of relative growth based on a fixed value (2004 = 100%) for controlled landfill sites in operation [%].

	Number of controlled landfill sites in operation		Area of controlled landfill sites in operation		Area of landfill section/cells closed during the year	
Cities	Total	Urban areas	Total	Urban areas	Total	Urban areas
Polska	50.24	58.18	64.92	74.22	261.54	220.69
Dolnośląskie	31.97	44.83	55.86	66.30	96.92	-
Kujawsko-pomorskie	64.29	75.00	72.90	57.59	-	-
Lubelskie	46.40	76.92	55.76	61.24	142.86	-
Lubuskie	51.52	50.00	71.57	76.17	2450.00	1000.00
Łódzkie	54.55	14.29	60.64	21.38	132.00	-
Małopolskie	72.97	89.47	106.28	106.78	-	-
Mazowieckie	67.78	80.00	79.50	124.21	1043.75	375.00
Opolskie	53.33	100.00	56.48	93.12	-	-
Podkarpackie	51.02	57.14	51.50	39.75	-	-
Podlaskie	33.73	37.50	42.55	31.72	50.00	-
Pomorskie	72.34	80.00	68.44	32.22	594.74	-
Śląskie	63.41	74.07	89.49	100.27	51.09	69.12
Świętokrzyskie	46.67	60.00	62.55	78.43	-	-
Warmińsko-mazurskie	31.82	22.22	24.84	12.54	191.67	-
Wielkopolskie	49.11	26.67	72.84	52.10	1120.00	-
Zachodniopomorskie	52.73	40.00	103.84	169.38	630.77	-

In the year 2012, in all voivodships, there was a decrease in the number of controlled landfill sites in operation situated in cities in comparison to the year 2004. The trend goes along with the data on the municipal waste from urban and rural areas. The opolskie voivodship is an exception with no change in the number of landfill sites in operation in the discussed years. The steepest decrease was observed in the voivodships: łódzkie (85.71%), warmińsko-mazurskie (77.78%) and wielkopolskie (73.33%). The reduction of the number of controlled landfill sites in operation in cities did not always diminish their area. In some cities in the voivodships: mazowieckie,

małopolskie, śląskie and zachodniopomorskie, the number of landfill sites in operation was reduced, but at the same time their area increased in 2012 compared to 2004. The biggest increase of the area of controlled landfill sites occurred in the following voivodships: zachodniopomorskie (69.38%), mazowieckie (24.21%), and the smallest in the śląskie voivodeship (0.27%). The mazowieckie and śląskie voivodships saw an increase of the controlled landfill sites area in cities with a simultaneous decrease of the total area of landfill sites in both urban and rural areas. This leads to the conclusion that in these voivodships the area of controlled landfill sites in operation in the urban area increases and in the rural area decreases. Interestingly, in comparison to 2004, in 2012 an increase of the area of landfill section/cells closed during the year occurred with a simultaneous increase of the area of controlled landfill sites in operation. The only voivodeship with a decrease of the area of landfill section/cells during the year is the śląskie voivodeship (a drop of 30.88%).

5. Conclusions

The quantity of waste produced per capita during a year serves as an index which can be used in the assessment of the level of sustainable development in terms of environmental governance. Polish share in the total quantity of municipal waste in the EU in 2012 was 4.9%. That, with the amount of 314kg of waste per capita in 2012, ranked Poland 24th out of 27 EU countries. Only the Chech Republic, Latvia and Estonia had a smaller quantity of municipal waste per capita. Since 1 July 2013 Polish municipalities have been responsible for the waste management, and their decision making in this respect should go along the provisions of the waste management act. The extent of the sustainable development in cities in the analyzed period is determined by these provisions. The key activity in waste management is waste recovery with a special consideration of recycling. The implementation of recovery processes leads to the emergence of closed material flows where remains become valued resources which can be reintroduced into the economy. In contrast to recycling, neutralization through landfilling hinders the sustainable development of cities.

The quantity of municipal waste collected in cities in 2012 was smaller than in 2004 by 16.31%. Also the number and the area of landfill sites in cities shrank. Data show that the decrease of the waste collected in total and per capita in individual cities is a dominant trend. Municipal waste is a more complicated problem in spa cities though. The average annual quantity of waste collected per capita tends to be overestimated by the large tourist traffic connected with the resort functions of these cities.

The generation of municipal waste is inherent in the functioning of urban communities. Yet it is possible to minimize its negative environmental impact through proper waste management systems which, apart from ecological effects, can also bring economic and social perks. That is why municipal waste management is a significant element of the sustainable development of cities.

References

Pearson, L.J. (2013). In search of resilient and sustainable cities: Prefatory remarks. *Ecological Economics, 86*, 222.

Chen, W.Y., Wang, D.T. (2013). Economic development and natural amenity: An econometric analysis of urban green spaces in China. *Urban Forestry & Urban Greening, 12*, 435–442.

Zhenming, L., & Bin, X. (2013). Sustainability analysis of the urban ecosystem in Guangzhou City based on information entropy between 2004 and 2010. *Journal of Geographical Sciences, 23(3)*, 417-435.

McDonnell, M.J., & Hahs, A.K. (2013).The future of urban biodiversity research: Moving beyond the 'low-hanging fruit'. *Urban Ecosystems, 16*, 397–409.

Schäffler, A., & Swilling, M. (2013).Valuing green infrastructure in an urban environment under pressure - The Johannesburg case. *Ecological Economics, 86*, 246–257.

Jansson, Å. (2013). Reaching for a sustainable, resilient urban future using the lens of ecosystem services. *Ecological Economics, 86*, 285–291.

McCormick, K., Anderberg, S., Coenen, L., & Neij, L. (2013). Advancing sustainable urban transformation. *Journal of Cleaner Production, 50*, 1-11.

Jim, C.Y. (2013). Sustainable urban greening strategies for compact cities in developing and developed economies. *Urban Ecosystsystems, 16*, 741–761.

Mörtberg, U., Haas, J., Zetterberg, A., Franklin, J.P., Jonsson, D., & Deal, B. (2013). Urban ecosystems and sustainable urban development - analysing and assessing interacting systems in the Stockholm region. *Urban Ecosyststems, 16*, 763–782.

Zheng, H.W., Shen, G.Q., & Wang, H. (2014). A review of recent studies on sustainable urban renewal. *Habitat International, 41*, 272-279.

Vojnovic, I., & Darden, J.T. (2013). Class/racial conflict, intolerance, and distortions in urban form: Lessons for sustainability from the Detroit region. *Ecological Economics, 96*, 88–98.

Shaalan, I. (2013). Sustainable urban transformation in small cities in Egypt: a UN-habitat perspective. *Journal of Cleaner Production, 50*, 200-204.

Shen, L., Peng, Y., Zhang, X., & Wu, Y. (2012). An alternative model for evaluating sustainable urbanization. *Cities, 29*, 32–39.

Haas, T., & Troglio, E. (2013). Sustainable Urban Cells and the Energy Transect Modeling: Reconciling the Green and the Urban Proceedings of 53rd ERSA Congress Regional Integration: Europe, the Mediterranean and the World economy. Palermo, Italy, paper #377.

Phipps, M., Ozanne, L.K., Luchs, M.G., Subrahmanyan, S., Kapitan, S., Catlin, J.R., Gau, R., Naylor, R.W., Rose, R.L., Simpson, B., & Weaver, T. (2013). Understanding the inherent complexity of sustainable consumption: A social cognitive Framework. *Journal of Business Research, 66*, 1227–1234.

Ustawa z dnia 14 grudnia 2012 r. o odpadach, Dz.U. 2013 poz. 21.

Chwesiuk, T., Kijewska, K. & Iwan, S. (2010). Urban consolidation centres for medium-size touristic cities in the Westpomeranian Region of Poland . *Procedia Social and Behavioral Sciences, 2*, 6264–6273.

Kijewska, K., Iwan, S. & Kaczmarczyk, T. (2012). Technical and organizational assumptions of applying UCCs
to optimize freight deliveries in the seaside tourist resorts of West Pomeranian Region of Poland. *Procedia - Social and Behavioral Sciences, 39*, 592 – 606.

Zaman, A.U., & Lehmann, S. (2013). The zero waste index: a performance measurement tool for waste management systems in a 'zero waste city'. *Journal of Cleaner Production, 50*, 123-132.

Seroka-Stolka, O. (2013). Poziom świadomości ekologicznej przedsiębiorców jako element zrównoważonego rozwoju-analiza porównawcza. *Journal of Ecology and Health*, *15*, 159-165.

Getahun, T., Mengistie, E., Haddis, A., Wasie, F., Alemayehu, E., Dadi, D., Van Gerven, T., & Van der Bruggen, B. (2012). Municipal solid waste generation in growing urban areas in Africa: current practices and relation to socioeconomic factors in Jimma, Ethiopia. *Environmental Monitoring and Assessment, 184*, 6337–6345.

Pandey, P.C., Sharma, L.K., & Nathawat, M.S. (2012). Geospatial strategy for sustainable management of municipal solid waste for growing urban environment. *Environmental Monitoring and Assessment, 184*, 2419–2431.

Thanh, N.P., & Matsui, Y. (2013). Assessment of potential impacts of municipal solid waste treatment alternatives by using life cycle approach: a case study in Vietnam. *Environmental Monitoring and Assessment, 185*, 7993–8004.

Noma, T., Ide, K., Yoshikawa, J., Kojo, K., Matsui, H., Nakajima, R., & Imai, K. (2012). Development of waste gasification and gas reforming system for municipal solid waste (MSW). *Journal of Material Cycles and Waste Management, 14*, 153–161.

Menikpura, S.N.M., Gheewala, S.H., Bonnet, S., & Chiemchaisri, C. (2013). Evaluation of the Effect of Recycling on Sustainability of Municipal Solid Waste Management in Thailand. *Waste and Biomass Valorization, 4*, 237–257.

Zhang, Y., Huang, G.H., & He, L. (2014). A multi-echelon supply chain model for municipal solid waste management system. *Waste Management, 34*, 553–561.

Miyata, Y., Shibusawa, H., & Hossain, N. (2013). An Economic Analysis of Municipal Solid Waste Management of Toyohashi City, Japan: Evidences from Environmental Kuznets Curve. Proceedings of 53rd ERSA Congress Regional Integration: Europe, the Mediterranean and the World economy. Palermo, Italy, paper #137.

Nitkiewicz, T. (2010). The potential of LCA use in the sustainability evaluation process. In V. Modrák & T. Nitkiewicz (Eds), *The role of business in achieving sustainability. PART 1: Instruments and Strategies*. Prešov: University of Košice.

Ustawa z dnia 13 września 1996 r. o utrzymaniu czystości i porządku w gminach, Dz.U. 1996 nr 132 poz. 622

Ustawa z dnia 1 lipca 2011 r. o zmianie ustawy o utrzymaniu czystości i porządku w gminach oraz niektórych innych ustaw, Dz.U. 2011 nr 152 poz. 897.